Abstract

Muses-C Nanorover Mission and Related Technology

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Recent advances in microtechnology and mobile robotics have made it feasible to create extremely small automated or remote-controlled vehicles which open new application frontiers. One of these possible applications is the use of nanorovers (robotic vehicles with a mass of order 100 grams) in planetary exploration. Such vehicles could be used, for example, to survey areas around a lander, or even to conduct long-range missions of exploration doing surface chemical analysis or looking for a particular substance such as water ice or microfossils. The objective of this current development is to create a useful nanorover system using current-generation technology including mobility, computation, power, and communication with a mass of a few hundred grams, and also to advance selected technologies which offer breakthroughs in size reduction, mobility, or science return to enable complete rovers to be built with a mass well under 100 grams.

NASA Code-S planetary missions have been under increasing pressure to reduce their launch mass requirements so that less expensive launch vehicles can be used. In order to launch on these inexpensive vehicles, significant reductions in mass must be achieved. To achieve those aspects of scientific exploration requiring mobility, any rover component of the science payload must compete effectively in terms of mass against other payload options. Microrovers (~10kg) were conceived partly in response to this [1], and soon after nanorovers (10's or 100's of grams) were proposed for the same reasons [2]. Nanorover technology will allow mobility-based science surveys, such as mineralogic classification, and the search for water ice or other volatiles, microfossils, or other entities at or very near the surface with a small, perhaps negligible, fraction of the science payload for Mars Surveyor or Discovery class missions. This latter point makes it conceivable that nanorovers could fly as a secondary payload on most landers using whatever mass margin is left over at launch time. Alternatively, they could be the prime payload of microlanders for Mars or the moons of the gas giant planets. They can become the entire spacecraft for solar sail missions to small bodies anywhere in the inner solar system. The vehicle developed thus-far is now baselined for NASA participation in the Japanese MUSES-C mission which will return a sample from a near-Earth asteroid, launching in 2002 or 2003.

A high-mobility vehicle configuration which can meet the mission and science requirements has been developed. A "posable strut" concept is used to provide a self-righting and/or upside-down-operable articulated vehicle chassis. It includes the ability to recover from overturning as well as body pose control for camera/instrument pointing, sampling, or other functions. Operation in extremely low gravity (e.g. on the surface of an asteroid) can be accomplished since no free pivots

are used (which would have too much friction to articulate freely in a microgravity environment). No prior vehicles are known which combine many or most of the desirable features achieved in this design:

* can operate upside down
* can intentionally flip over and recover from accidental overturning
* can place or point the body faces in contact or parallel to the ground (e.g. for sensor placement)
* can lift wheels and set them on top of obstacles (instead of pushing the wheel against the obstacle and requiring enough traction to lift the wheel against gravity)
* can articulate to keep all wheels providing optimum traction even in arbitrarily low gravity fields
* can "hop" and reorient the body during ballistic hops in very small gravity fields